Hawai'i
Biodiversity
Research &
Interspecies
Dynamics

Dr. Steven Birch
Director of Research
Hawai'I Biodiversity Research &
Interspecies Dynamics
2463 South Kihei Road C16-217
Kihei, HI 96753

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Donna Wieting,
Chief of Marine Mammal Conservation Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, MD 20910-3226

RE: NAVY SURTASS LFA DEPLOYMENT

Dear Ms. Wieting

As a biomedical engineer with expertise in cetacean biology, underwater acoustics, human neurophysiology and mechanical resonance effects, I am concerned about the proposed deployment of the Navy SURTASS LFA sonar. Close examination of the Final Environmental Impact Statement (FEIS) reveals a number of worrying omissions. Given the requirements for the FEIS to conform to standard scientific practice, these gaps in the demonstrated knowledge base of the FEIS are a grave case for concern as to the accuracy and validity of the FEIS as a decision making document.

These omissions, itemized in detail within this submission, fall into the 3 following categories:

1. Resonance frequency effects in fish, turtles, marine mammals and humans have been dismissed without giving an adequate review of the literature to justify such a position. Theoretical models of resonant frequency calculation have been totally ignored.

2. Offshore Biologically Important Area determination does not discuss or include a number of evident areas which can be found in any freshman college textbook. Global impacts are modeled and deemed negligible but little concern is given about localized effects in such areas

3. HF/M3 marine mammal detection system is not able to detect more than 55% of dolphins traversing the beam, raising doubts about the overall efficacy of the system.

The potential impact of resonant frequency effects in OBIAs and within the context of failed HF/M3 detection procedures is evidently not addressed within the FEIS, as part of the lack of discussion outlined in point (1).

ITEMIZED CONCERNS ABOUT SURTASS LFA
FINAL ENVIRONMENTAL IMPACT STATEMENT

1. NON AUDITORY INJURY. RESONANCE PHENOMENA

1.1 ARPA reference not applicable

In the main body of the FEIS (ref. 4.1.1.1), this topic is given a total of 12 lines of attention. These begin with a couple of references which suggest that the resonant frequency of fish swim bladders are above the frequency of best hearing, leading to the quoted conclusion that: "Therefore, it is not expected that resonance of the swim bladder would play a significant role in response to LF sound (ARPA 1995)".This particular reference is from the Advanced Research Projects Agency evaluation of the ATOC system, and thus dealing with a 75Hz signal which does not correspond to the frequencies to be used (100-500Hz) by SURTASS LFA. This conclusion is therefore not applicable in the context of the FEIS. (ARPA 1995: FEIS; p.13.1)

1.2 Generalization based on only two species of fish

In the FEIS comments section (Comments 3.2.5), it is recognized that resonance frequencies of fish swim bladders exist and the values for two species are given, namely:

Northern Anchovies	5inches in length	f_{res} = 1.3 kHz
Cod	14 inches in length	f_{res} = 400-560 Hz

The FEIS states that " fish are not expected to be significantly affected because SURTASS LFA is lower in frequency than the resonance for even the larger fish". This is not immediately evident given that: (a)the resonant frequency range for a 14 inch cod includes the 400-500Hz band which falls within the range given for SURTASS LFA (100-500Hz).(b) resonant frequency varies as a function of gas volume and depth, as outlined in 1.6. Furthermore, extrapolating from two species to the entire range of species found in the oceans seems a tenuous link at the very least.

1.3 Inaccurate generalization about pelagic fish species

In section 4.1.1.1 it further states that only larger pelagic fish (for example tuna) could have swim bladders whose resonant frequencies would fall within the range of the SURTASS LFA, but that these fish are unlikely to be affected as they spend most of their time near the surface. This comment is not consistent with data pertaining to dolphin-tuna interactions, in which schools of tuna are commonly found swimming at depth beneath dolphin pods. This comment is also not consistent with information gleaned from deep sea fishermen. These inconsistencies are grounds for suspicion as such data should not only be easily obtainable by EIS authors, but included and discussed within the FEIS.

1.4 Omission of relevant theoretical models

Nowhere within the FEIS is there mention of the theoretical models for calculations of the resonant frequencies of gas bubbles. This omision is of concern as it suggests that either an incomplete literature review was conducted in the preparation of the FEIS, or that such information was deliberately omitted. These two models are:

Minnaert's theory f_{res} = [660 * SQRT(pressure)] / lung diameter
Andreeva / Barham f_{res} = (1/2piR)*SQRT[(3gP+4u)/q]

It should be noted that these two models were included in the NATO SACLANTCEN Bioacoustics Panel, June 15-16 1998 report: Acoustic Analysis of SWAC4 Phase II, authored by McMullen & McCarthy of United States Naval Undersea Warfare Center.
It should also be noted that Barham of the former NUC (Naval Undersea Center), now NRaD, expanded the work of Andreeva in 1973. This suggests that at least within NRaD and NUWC there is some awareness of these issues which should have been addressed within the FEIS.
Even in the case of such mathematical models being inaccurate, acknowledging their existence and explaining their omission seems a necessary part of the FEIS, especially to comply with the requirements of scientific accuracy of this document.

1.5 Awareness of resonance phenomena
Within the FEIS is included a letter
From: Commanding Officer
To: Chief of Naval Operations, Attn: Director Submarine Warfare Division
Via: Chief, Bureau of Medicine and Surgery
Commander, Naval Sea Systems
Subject: Interim Guidance for Operation of Low Frequency Underwater sound sources in the presence of recreational divers
subnote (d) reads:
"Evidence did suggest that lung resonance did increase as a function of diver depth and at deeper depth (>200ft) lung resonance could be possible within the guidance frequency band but would not cross 150Hz until between 600 and 700 foot depths. Equipment used by divers during testing included neoprene wetsuits"

Irrespective of the human diver perspective, this document further indicates awareness of resonance effects on gaseous bubbles (aka. lungs, swim bladders, etc), an awareness which highlights the complete absence of modeling of fish, turtle and marine mammal resonance frequencies, which would be expected within the confines of scientific accuracy required of the FEIS. Furthermore, two enclosures are referred to by this letter, and it should be noted that Enclosure 2: "Draft NSMRL Technical Report: Summary Report on the Bioeffects of low frequency water borne sound" is missing from the FEIS, when, from the title alone, it appears to hold information pertinent to this topic.

1.6 Omission of relevant scientific literature
Aburto of NOSC (SPAWAR: Space and Naval Warfare Systems Command), in an email submission to the Bioacoustics List at Cornell University dated 03 Jun 1997, dealt further with the Andreeva/Barham model for resonant frequency determination and provided sample calculations for mammalian lung volumes of 2 and 2000 litres. His concise examples allow for the easy calculation of resonant frequencies for any gas body volume at depth. Such calculations are presented in Tables 1.1 and 1.2 for a range of representative volumes.

The validity of the Andreeva/Barham equation appears to have been vindicated by holographic interferometry studies of fish swim bladders (Vaitulevich 1974, Altmann 1984). Altmann further concludes that the swimbladder wall vibrates with the greatest amplitude at stimulation frequencies close to the base resonance frequency and at frequencies corresponding to the 2nd and 3rd harmonics. With such information being readily available, it is a matter of concern that the FEIS makes no attempt to calculate and/or discuss these data.

1.7 Calculated resonance frequencies fall within SURTASS LFA range

Resonant frequencies calculated using Aburto/Barham formula are presented in tables 1.1 and 1.2. As a point of size comparison, 10 year old human male children have a lung volume of approx. 1.6 litres, 20-30 year olds have a 6.0 litre volume. Females are usually 25% smaller than males. (Schmidt & Thews 1983) Finback whales are reported as having a lung volume of 2000 litres, Cuvier's Beaked whales 136 litres and Bottlenose dolphins 3.5 litres. (NATO SACLANTCEN 1998) Assuming that some pelagic fishes, turtles, small seals, etc may have gaseous spaces whose volumes are in the range 0.1 –1.0 litres (ie smaller than a human 10 year old), table 1.2 reveals that a substantial range of frequencies for these gas volumes falls within the SURTASS LFA active range (100-500Hz) for depths up to and exceeding 100 metres.

Depth(m)	Lung Volume in Litres							
	0.001	0.01	0.1	1	10	100	1000	10000
0	601.0412	278.9786	129.4904	60.10412	27.89786	12.94904	6.010412	2.789786
5	770.6095	357.6853	166.0228	77.06095	35.76853	16.60228	7.706095	3.576853
10	930.327	431.8195	200.4329	93.0327	43.18195	20.04329	9.30327	4.318195
15	1083.505	502.9183	233.434	108.3505	50.29183	23.3434	10.83505	5.029183
20	1231.802	571.7517	265.3836	123.1802	57.17517	26.53836	12.31802	5.717517
30	1517.393	704.3115	326.9125	151.7393	70.43115	32.69125	15.17393	7.043115
40	1791.845	831.7006	386.0412	179.1845	83.17006	38.60412	17.91845	8.317006
50	2057.735	955.1159	443.3255	205.7735	95.51159	44.33255	20.57735	9.551159
100	3301.705	1532.516	711.3308	330.1705	153.2516	71.13308	33.01705	15.32516
200	5550.444	2576.288	1195.807	555.0444	257.6288	119.5807	55.50444	25.76288
300	7624.436	3538.95	1642.635	762.4436	353.895	164.2635	76.24436	35.3895
400	9589.645	4451.119	2066.026	958.9645	445.1119	206.6026	95.89645	44.51119
500	11476.75	5327.034	2472.59	1147.675	532.7034	247.259	114.7675	53.27034

Table 1.1: Resonant Frequencies calculated for different gas bubble volumes, per Aburto (1997). Frequencies falling within the 100-500Hz SURTASS LFA range are shaded

Depth(m)	Lung Volume in Litres								
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	129.4904	102.7766	89.78362	81.57384	75.72644	71.26131	67.69213	64.7452	62.25249
5	166.0228	131.7724	115.1138	104.5878	97.09072	91.36586	86.78974	83.0114	79.81543
10	200.4329	159.0837	138.9724	126.2648	117.2139	110.3025	104.7779	100.2164	96.35807
15	233.434	185.2767	161.8541	147.0542	136.513	128.4637	122.0295	116.717	112.2233
20	265.3836	210.6351	184.0067	167.1812	155.1973	146.0462	138.7314	132.6918	127.5831
30	326.9125	259.4706	226.6684	205.9419	191.1796	179.9069	170.8961	163.4562	157.1631
40	386.0412	306.4011	267.666	243.1907	225.7583	212.4467	201.8061	193.0206	185.5893
50	443.3255	351.8677	307.3847	279.2776	259.2583	243.9714	231.7519	221.6628	213.1287
100	711.3308	564.5837	493.2093	448.1103	415.9888	391.4604	371.8539	355.6654	341.9722
200	1195.807	949.1126	829.1262	753.3112	699.3121	658.0779	625.1176	597.9035	574.884
300	1642.635	1303.76	1138.939	1034.795	960.6187	903.9768	858.7005	821.3175	789.6965
400	2066.026	1639.806	1432.503	1301.515	1208.22	1136.978	1080.032	1033.013	993.2419
500	2472.59	1962.496	1714.398	1557.634	1445.979	1360.719	1292.566	1236.295	1188.697

Table 1.2: Calculated resonant frequencies for gas bubble volumes in the range 0.1 – 0.9 litres Frequencies falling within the 100-500Hz SURTASS LFA range are shaded

It should be noted that resonance phenomena can occur with lesser energy requirements than for non resonance. The fundamental frequency of a gas volume is that frequency at which it is most susceptible to excitation. This raises the issue that the 180dB mitigation area for the SURTASS LFA may not be an adequate measure, as resonance phenomena may be possible at much lower RLs.

Such issues, calculations and mathematical modeling of potential target species are completely absent from the FEIS. Given the stringent requirements for the FEIS to make due regard to scientific process, these omissions raise grave concern about the accuracy and validity of the EIS.

2. OFFSHORE BIOLOGICALLY IMPORTANT AREAS (OBIAs)

2.1 Omission of whale migration routes

In the FEIS (FEIS 2.11), OBIAs are defined as including:

* Migration corridors
* Breeding and Calving Grounds
* Feeding Grounds

With this information in mind, it is of concern that within the FEIS whale migration corridors are not shown or acknowledged, despite the fact that such migration paths are known to exist and have been determined through satellite tracking.

2.2 Omission of generally accepted OBIA

Opening a freshman biology text (Cox, 1993) provides the following pertinent information.

"For purposes of productivity analysis, oceans are divided into 4 zones: open ocean, upwelling zones, continental shelf and reef-estuary systems. Upwelling zones are the most productive offshore areas, followed by continental shelf regions."

The FEIS acknowledges that in general the continental shelf is bounded by the 12nm exclusion zone for SURTASS LFA, but in some locations it extends far beyond this range.

It is therefore of concern that the FEIS does not take into account such areas in the discussion of OBIAs, and furthermore, that the upwelling areas found along the western coasts of the United States, South America, Africa, India and the Gulf of Oman are not even considered.

2.3 No modeling of localized Non Auditory Injury in excluded OBIAs

Taking into account the unknown resonance effects of the SURTASS LFA signal on local fish and marine mammal populations, the limited number of OBIAs is a matter of concern. Although the modeling in the FEIS suggests a negligible impact on the global populations of species, the possibility of negatively impacting localized populations on which island economies may be dependent cannot be discounted.

3. HF/M3 MARINE MAMMAL DETECTION

3.1 Cases of limited efficacy of system

Within the FEIS section on the HF/M3 marine mammal detection system, it is stated that during testing, small cetaceans traversing the HF/M3 detection zone were only detected in 55% of cases (11 out of 20). This raises the concern that in 45% of cases, small animals may not be detected and be exposed to injurious levels within the mitigation zone.

3.2 Inability of other systems to detect marine mammals

The NATO SACLANTCEN report on Acoustic Analysis of SWAC 4 Phase II states as its objective: "to acoustically detect the presence of marine mammals in Runs 9 and 10 of the SWAC-4 sea test" and concludes that: "marine mammals have not been detected passively or actively in the acoustic data analyzed". This inability to detect marine mammals, conveniently attributed to an error in the third significant bit of the acoustic data from the towed array hydrophone, is concerning as on that date (12 may 1996), a mass stranding of Cuvier Beaked whales occurred on the coast within 20km of the testing area.

Albeit a different system than the SURTASS LFA, this inability to obtain uncorrupted data and further inability to detect marine mammals raises concerns about the reliability of the HF/M3 system incorporated into the SURTASS LFA

References:

- Aburto A, (1997): Whale resonant lung volume calculations, Bioacoustics-L@cornell.edu, 03. jun. 1997.
- Altmann, Butosov, Vaitulevich & Sokolov (1984): Responses of the swimbladder of the carp to sound stimulation, Hearing Research 14: 145-153.
- Andreeva (1964): Scattering of sound of bladders of fish in deep sound scattering ocean layers, Soviet. Phys. Acoust. 10: 20-24.
- Barham (1973): Whale respiratory volume as a possible receiver for 20Hz signals, Nature 245: 220-221.
- Cox (1997): Conservation Biology:concepts and applications, Wm.C.Brown, pp 168-169.
- Vaitulevich & Ushakov (1974): Holographic study of swimbladder vibrations in Cyprinus carpo, Biofizika 19(3): 528-533
- Schmidt & Thews (1983): Human physiology, Springer Verlag, Berlin.
- Department of the Navy (2001): Surveillance Towed Array Sensor System Low Frequency Active Sonar (SURTASS LFA): Final Environmental Impact Statement
- NATO UNCLASSIFIED DOCUMENT
  McMullen & McCarthy (1998): Acoustic analysis of SWAC 4 Phase II, SACLANTCEN Bioacoustics Panel. (NUWC: Naval Undersea Warfare Center | ONR: Office of Naval Research | NSSC: Naval Sea Systems Command)

As outlined in sections 1 through 3 above, these omissions from the FEIS raise concerns about the validity of said document. Within the requirements section of the FEIS, it is stated that it was to be generated with due attention to the scientific process.
Irrespective of motive, the omissions noted above suggest a lack of attention to relevant detail, thus leading to an FEIS lacking in sufficient information to allow informed decision making to be attained by relevant authorities.

Given the global scope of the SURTASS LFA system, it behooves decision makers to be adequately informed of all aspects of this technology prior to committing to the deployment of such a system. The FEIS as it stands does not appear to be such a document, and certainly does not appear comprehensive enough to justify the granting to the Navy of a Letter of Authorization (LOA) by the National Marine Fisheries Service.

Due to the growing public demand for congressional oversight hearings into the LFA program, this letter outlining concerns with the FEIS has been forwarded to Government representatives.

Yours sincerely

Steven Birch
B.Sc(hons) Ph.D (biomed eng)

CC:
Senator Daniel K Inouye
722 Hart Senate Office Building
Washington, D.C. 20510

Senator Daniel Akaka
141 Hart Senate Office Building
Washington, D.C. 20510

Representative Patsy Mink
2135 Rayburn House Office Building
Washington, DC 20515

Representative Neil Abercrombie
1502 Longworth House Office Building
Washington, D.C. 20515